

ACMS Statistics Seminar

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154 Hurley Hall
3:30 PM – 4:30 PM

Diffusion Models: Tight Convergence Guarantees and Training-Free Acceleration

The past few years have witnessed the emergence of diffusion models as a leading generative paradigm, achieving top performance across a wide range of applications. Despite the empirical success, the theoretical understanding of diffusion models, including tight convergence analyses of widely used samplers and training-free acceleration, remains largely underexplored. In this talk, I will present our recent progress on diffusion models. In the first part of the talk, I will introduce a sharp convergence theory for the Denoising Diffusion Probabilistic Model (DDPM), which significantly improves upon prior convergence guarantees for this sampler. Our convergence analysis is tight for a wide array of target distributions. These results also challenge the prevailing view that DDPM is inherently slower than the Denoising Diffusion Implicit Model (DDIM) due to linear dependence on the dimension d : we prove that DDPM and DDIM share the same d -dependence. The second part of the talk focuses on provable acceleration of diffusion models. We propose a novel training-free acceleration algorithm, leveraging high-order Lagrange interpolation and successive refinement to approximate the integral derived from the probability flow ODE. We prove that, to achieve ϵ -precision in total variation, our algorithm requires only the order of $d^{1+2/K} \epsilon^{-1/K}$ score function evaluations (up to log factors) in the presence of accurate scores, where K is an arbitrarily large fixed integer.

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